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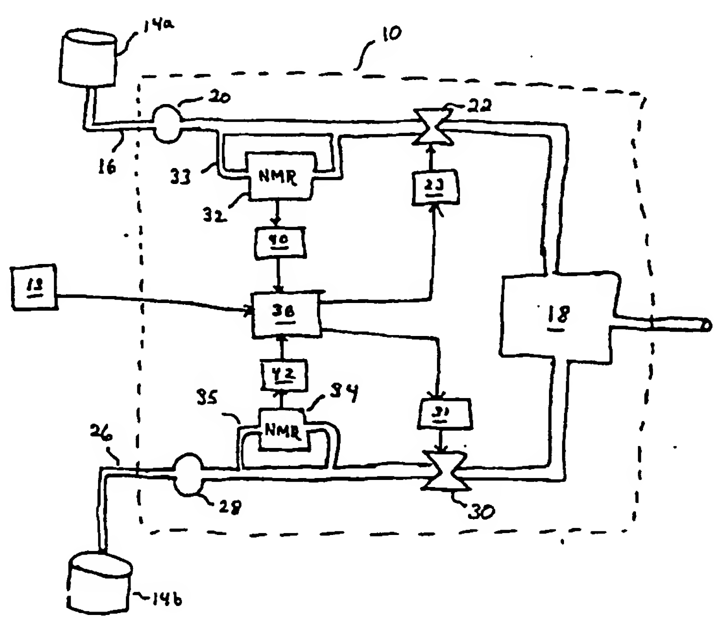
(54) Title: CRUDE OIL BLENDING METHOD AND SYSTEM



(57) Abstract: A method for blending two or more constituents into a petroleum mixture employs nuclear magnetic resonance to obtain real-time estimates of selected properties of at least one of the constituents. A multivariate controller processes these estimates to determine the relative amounts of each constituent that are required to form a petroleum mixture having desired values of those selected properties.

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

CRUDE OIL BLENDING METHOD AND SYSTEM

This invention relates to oil refining methods and systems, and in particular to methods and systems for blending a variety of crude oils to achieve a blended petroleum mixture having desired physical and chemical properties.

BACKGROUND

Crude oil, also known as petroleum, is a complex mixture of hydrocarbons. In the process of manufacturing commercially useful petroleum products, these component hydrocarbons are separated from one another. The various physical and chemical processing steps for separating crude oil into component hydrocarbons are collectively referred to as "refining."

A difficulty associated with the refining of crude oil is the variability in the properties of the crude oil. For example, there exist crude oils that, at room temperature, have a consistency similar to that of heavy motor oil. There also exist crude oils that, at the same temperature, have the consistency of asphalt. Although commonly thought of as black, crude oil can be brown, yellow, green, or red. There even exist crude oils that are fluorescent. These differences are manifestations of vastly different hydrocarbon mixtures found in different oil fields throughout the world.

The physical and chemical processes associated with refining crude oil depend, to a great extent, on the oil's physical and chemical properties. These properties, in turn, depend on the oil's component hydrocarbons and their respective concentrations. Because of the extreme variations in the composition of crude oil, the extent to which these refining processes vary is such that one cannot readily construct a refinery that is optimized for the different varieties of crude oil available. As a result, it is common practice in the refining industry to blend several varieties of crude oil to form a petroleum mixture appropriate for the processes carried out at that refinery.

The process of blending several varieties of crude oil to form a petroleum mixture appropriate for a particular refinery requires up-to-date knowledge of the values of selected properties of the various crude oil constituents of that mixture. These selected properties include the oil's aromaticity, boiling point, flash point, cloud point, viscosity, pour point, API gravity, freeze point, octane, PIONA, and RVP. It is not, however, a simple matter to obtain quantitative knowledge of these properties.

The above-mentioned properties of crude oils can be obtained through gas chromatography. However, this process is impractical for heavy-weight crudes because heavier components present in such crudes are insufficiently volatile to be desorbed from the chromatography column. These heavier components tend to remain in the column, thereby rendering the column unusable for further tests.

An alternative method for obtaining physical and chemical properties of a crude oil is to observe the interaction of the crude oil with infrared radiation. However, this method is sensitive to the opacity of the crude oil. It is therefore ineffective for heavier, highly opaque crudes. In addition, the interaction between crude oil and infrared radiation is highly non-linear and temperature sensitive.

Another method for obtaining the physical and chemical properties of crude oil is to perform laboratory tests on a sample. This, however, is a costly and time-consuming process. Because the crude oil varieties available for blending change from one tanker-load to the next, it is difficult to perform laboratory testing frequently enough to maintain up-to-date information about the properties of all crude oil varieties available for blending at any one time. Consequently, this method is not suitable for real-time control over the values of selected properties of the petroleum mixture.

It is thus an object of the invention to provide a method and system for obtaining up-to-date information concerning values of selected properties of one or more crude oil varieties and for blending those varieties to obtain a petroleum mixture having desired values of those selected properties.

SUMMARY

The method of the invention overcomes deficiencies in the prior art by performing real-time and on-line estimates of the values of selected properties of at least one constituent crude available for blending into a petroleum mixture. The result of this real-time estimate, together with the properties of the desired petroleum mixture, are provided to an automated controller. The controller calculates, in real-time, the correct amount of the constituent crude required to produce a petroleum mixture having desired values of the selected properties. Because the estimates are performed in real-time, a system incorporating the invention dynamically alters the relative amounts of the constituents of the blended petroleum mixture in response to variations in the values of the selected properties of each of the constituent crudes. The term real-time is used herein in a relative

sense, with time typically measured in seconds or minutes. Such times suffice for control of crude oil blending on a commercial basis.

A preferred practice of the invention employs nuclear magnetic resonance measurements in conjunction with the estimation of values of selected properties of each constituent crude. NMR measurements do not rely on optical or infrared radiation, and are therefore not affected by high opacity. Additionally, NMR measurements are relatively stable as a function of temperature. Consequently, reliable measurements can be made at the relatively high temperatures to which crude oils are often heated to move them through a pipeline.

One practice of the invention includes the steps of imposing a steady magnetic field on a sample of a first constituent crude oil. With the steady magnetic field in place, an NMR sensor imposes a transient magnetic field on the first constituent and measures the response of the first constituent to this transient magnetic field. An NMR sensor generally does not provide values of the selected properties of the first constituent crude oil directly. Instead, the NMR sensor provides information regarding the chemical composition of the first constituent. More particularly, NMR measurements provide a spectroscopic designation of hydrogen chemistry present in the sample of material being measured. For this reason, the method of the invention includes the step of estimating the properties of the first constituent on the basis of its NMR measurement. Consequently, a computer system estimates, on the basis of this response, values of selected properties of the first constituent. These properties are then used to selectively blend the first constituent with a second constituent to form a blended petroleum mixture having desired values of selected properties. Examples of these selected properties include aromaticity, boiling point, flash point, cloud point, viscosity, pour point, API gravity, freeze point, octane, PIONA, and RVP.

The desired values of selected properties of a petroleum mixture are generally specified by an optimizer on the basis of constraints imposed by the particular refinery that is to process the blended petroleum mixture. However, the choice of these desired values can also be influenced by economic factors, such as the price and availability of different crudes and the sale price and demand for various products refined from the blended petroleum mixture.

The method of the invention can be implemented with a feedback system that estimates the values of selected properties of the blended petroleum mixture and compares

those estimated values with the desired values of those selected properties. The difference between the estimated values of the selected properties and the desired values of those properties is then used to adjust the relative quantities of the various constituents of the blended petroleum mixture. Preferably, this estimate of the values of selected properties of the blended petroleum mixture is also made by using nuclear magnetic resonance to first determine NMR-responsive information regarding the composition and more particularly regarding the hydrogen chemistry of the blended mixture and by then estimating the values of the selected properties of the mixture from that measured information.

The method of the invention can thus provide real-time estimates of the values of selected properties of a variety of crudes. Because the method of the invention relies on NMR rather than on optical techniques, the accuracy of these estimates can be essentially independent of the opacity or the temperature of the crude oil. As a result, the method of the invention is eminently suitable for blending a broad variety of crudes into a blended petroleum mixture having desired values of selected properties.

A system for practice of the invention includes an optimizer for specifying desired values of selected properties of the petroleum mixture to be formed. The optimizer specifies the desired values on the basis of the characteristics of the refinery and, optionally, on the basis of economic factors.

The system further includes a sensor for estimating the values of selected properties of at least one constituent available for blending into the mixture. These estimates, together with the desired values specified by the optimizer, are provided to a controller. On the basis of the estimated values from the sensor and the desired values from the optimizer, the controller determines the relative amounts of the constituents that are needed to form a petroleum mixture having the desired values of the selected properties.

With the foregoing techniques, as described further below, the method and apparatus according to the invention enable minimizing the variability of a crude petroleum mixture delivered to a refinery. Further, the mixture can be optimal for a particular refinery.

These and other features and advantages of the invention will be apparent from the following detailed description and the accompanying figures in which:

DESCRIPTION OF THE FIGURES

FIG. 1 shows a feedforward crude blending control system embodying features of the invention;

FIG. 2 shows details of the control system of FIG. 1; and

FIG. 3 shows a modification of the control system of FIG. 2, configured to operate as a feedback control system.

DETAILED DESCRIPTION

A petroleum blending system **10** incorporating principles of the invention accepts inputs from a tank farm **12** having a plurality of storage tanks **14a-n**, three of which are shown in FIG 1. These inputs are typically different varieties of crude oil, each characterized by an input vector of properties. These input vectors are indicated in FIG. 1 by the symbols $\mathbf{x}_1$, $\mathbf{x}_2$, ...$\mathbf{x}_n$ associated with the individual storage tanks. The elements of a typical input vector $\mathbf{x}_i$ include values representing selected physical and chemical properties of the crude oil. The output of the blending system **10** is a blended mixture of the varieties of crude oil available in the tank farm **12**. This blended mixture of crude oils is characterized by an output vector y having elements representative of selected physical and chemical properties of the blended mixture. Examples of these selected properties include viscosity, aromaticity, API gravity, and the like.

Although FIG. 1 illustrates different variation of crude oil being piped to the refinery from a tank farm, other sources of crude oil are available. For example, one or more crude oil varieties may reach the refinery by pipeline directly from a well-head or from an oil tanker. Alternatively, the varieties of crude may reach the well from different tank farms.

The petroleum blending system **10** selects the amounts of the individual crude oils required to achieve a blended mixture having an output vector optimized, for example, to maximize the refinery's revenues. This optimized output is given by a setpoint vector **r** provided by an optimizer **13**. This setpoint vector **r** includes elements representing desired values of selected properties of the blended petroleum mixture. The optimizer **13** determines the setpoint vector on the basis of constraints imposed by the nature of the particular refinery that is to receive the blended petroleum mixture. In addition, the optimizer **13** can apply economic conditions, both present and forecast, to determine a setpoint vector. Such economic conditions can include purchase prices and availability of

the various types of crude oil, the sale prices and demand for various products made from crude oil and the costs associated with the manufacture of those products.

The optimizer **13** is typically implemented as software instructions executed on the programmable digital processor such as a general purpose digital computer. Information can be provided to the optimizer **13** by an operator using a keyboard. Alternatively, the optimizer **13** can accept information through a network connection. In one practice of the invention, the optimizer **13** is configured to monitor a global computer network, such as the internet, for key economic indicators to be used in determining the setpoint vector **r**. A suitable optimizer for practice of the invention is sold by Simulation Sciences of Brea, California under the name ROMEO.

The petroleum blending system **10** is thus a multivariate control system that operates on a plurality of input vectors $x_1, x_2, \ldots x_n$ to generate an output vector y that matches the setpoint vector r supplied by the optimizer **13**. The output vector y includes elements representing the actual values of the selected properties of the petroleum mixture. The illustrated control system of FIG. 1 is a feedforward system because the output y is not fed back as an input. However, as discussed below, the invention is equally applicable to a feedback control system.

FIG. 2 shows details of the petroleum blending system **10** of FIG. 1. As shown in FIG. 2, a first storage tank **14a** is connected to a first pipeline **16** for transport of a first variety of crude oil from the tank farm **12** to a blending station **18**. The first pipeline **16** includes a first pump **20**, to propel oil through the pipeline **16**, and a first valve **22**, to control the amount of oil delivered to the blending station **18**. The position of the first valve **22** is under the control of a first actuator **23**.

A second storage tank **14b** from the tank farm **12** is likewise connected to a second pipeline **26** for transport of a second variety of crude oil to the blending station **18**. The second pipeline **26** includes a second pump **28** to propel oil through the pipeline **26** and a second valve **30** to control the amount of oil delivered to the blending station **18**. The position of the second valve **30** is under the control of a second actuator **31**.

Between the first storage tank **14** and the blending station **18** is a first nuclear magnetic resonance (NMR) sensor **32** configured to sample the crude oil in the first pipeline **16** through a first shunt tube **33**. Similarly, between the second storage tank **24** and the blending station **18** is a second NMR sensor **34** configured to sample the crude oil in the second pipeline **26** through a second shunt tube **35**.

One preferred NMR sensor 32, 34 employs the technology of the I/A Series NMR equipment available from The Foxboro Company, Foxboro, Massachusetts, U.S.A.

The outputs of the first and second NMR sensors **32, 34** are provided to first and second chemometric modeling units **40, 42**. These chemometric modeling units **40, 42** transform the outputs of the NMR sensors **32, 34** into a format suitable for a multivariate controller **36** to which they are connected. In response, the multivariate controller **36** sends control signals to the first and second actuators **23, 31**. The first and second actuators **23, 31** control the positions of the valves **22, 30** in such a way that the output vector y, which is indicative of properties of the blended mixture, is within some tolerance of the setpoint vector **r** provided by the optimizer **13**. These properties can include aromaticity, boiling point, flash point, cloud point, viscosity, pour point, API gravity, freeze point, octane, PIONA, and RVP.

A suitable chemometric modeling unit can be implemented on a programmable digital processor as a look-up table or as a mathematical model. The chemometric modeling unit can be local to the NMR sensor, as shown in FIG. 2. Another optional practice locates the chemometric modeling unit in the multivariate controller **36**. However, the NMR sensors in the oil blending system **10** can also share a common chemometric modeling unit.

Both the optimizer **13** and the multivariate controller **36** and the chemometric modeling unit are preferably implemented as software instructions executed on a programmable digital processor. In practice, these instructions are executed on a general purpose digital computer. To meet demanding performance requirements, the optimizer **13** and the multivariate controller **36** can be implemented in hardware, software, or with a combination of hardware and software. A multivariate process controller suitable for practice of the invention is sold by Simulation Sciences Inc. of Brea, California under the trade name CONNOSIEUR. The specific implementation details of the multivariate controller **36** and the optimizer **13** are known to those of ordinary skill in the art and do not affect the scope of this invention.

Although the petroleum blending system **10** illustrated in FIG. 2 shows two distinct NMR sensors **32, 34**, it will be appreciated that a single NMR sensor can be used, on a time-shared basis, for both the first and second pipelines **16, 26**. However, depending on the details of refinery lay-out, distances between the individual storage tanks may make it impractical to connect two or more storage tanks with a single NMR sensor. In practice, a

single NMR sensor may service one, two, or more crude oil sources depending on constraints imposed by the refinery's layout and infrastructure.

In operation of the petroleum blending system **10** illustrated in FIGS. 1 and 2, the first pump **20** propels oil through the first pipeline **16**. A sample of this oil is diverted to the first NMR sensor **32** through the first shunt tube **33**. The remainder of the oil flows to the first valve **22**, and, to the extent that the first valve **22** is open, to the blending station **18**.

The NMR sensor **32** imposes a steady magnetic field on this sample to align the magnetic dipole moments associated with the molecules in the sample. With the steady magnetic field in place, the NMR sensor **32** then imposes a transient magnetic field having a direction different from, and preferably orthogonal to, that of the steady magnetic field. This transient magnetic field temporarily aligns the dipoles from the sample in a direction other than that in which the static magnetic field aligns dipoles. When the transient magnetic field is turned off, the dipoles in the sample spring back into the alignment imposed upon them by the steady magnetic field. As they do so, the dipoles generate an RF signal. The rate at which a particular dipole springs back to alignment with the steady magnetic field, and hence the frequency of the resulting RF signal, is characteristic of the type of molecule carrying that dipole. The RF spectrum thus generated provides a way of determining information regarding the chemical composition of the sample; more particularly, of determining the hydrogen chemistry of the sample.

The NMR sensor **32** thus provides information on the chemical composition of the crude oil sample in the pipeline **16**. It is known in the art to estimate corresponding values of selected properties from this measured composition-responsive information of the sample. This operation of converting the measured sample information into estimated values of selected properties is carried out by a first chemometric modeling unit **40** in communication with both the multivariate controller **36** and the NMR sensor **32**. The input information to the first chemometric modeling unit **40** is the sample-responsive information measured by the NMR sensor **32**. The output of the first chemometric modeling unit **40** is a corresponding set of estimated values of the selected properties. The second NMR sensor **34** and the chemometric modeling unit **42** operate in a manner identical to the first NMR sensor **32** and chemometric modeling unit **40**.

A chemometric modeling unit **40** suitable for practice of the invention is implemented by a digital processor executing instructions for estimating values of selected physical properties on the basis of the measured hydrogen chemistry of the crude oil

sample. These instructions implement procedures that are well-known to those of ordinary skill in the art. Such procedures include establishing look-up tables, interpolating between values in a look-up table, or implementing mathematical models for estimating values of the selected properties.

Although not required for practice of the invention, it is often desirable to place a third NMR sensor **44**, together with an associated third chemometric modeling unit **46**, at the output of the blending station **18**, as shown in FIG. 3. This third NMR sensor **44** and its associated third chemometric modeling unit **46** operate in a manner identical to that discussed above in connection with the first NMR sensor **32** and its associated chemometric modeling unit **40**. The output of the third chemometric modeling unit **46**, which represents estimates of values of selected properties of the blended petroleum mixture, is fed back to the multivariate controller 36. With this third NMR sensor **44** in place, for example, the multivariate controller **36** can detect anomalies in the blended petroleum mixture that may be indicative of a system malfunction. In addition, the output of the third NMR sensor **44** can provide a feedback variable that the multivariate controller **36** processes to enhance generating the controlled variables, such as value positions, to attain the desired petroleum mixture.

As shown in FIGS. 2 and 3, the NMR sensors **32, 34, 44** each have individual chemometric modeling units **40, 42, 46** associated with them. However, the blending system **10** can also be implemented with a single chemometric modeling unit connected to each of the NMR sensors and used by each NMR sensor on a time-sharing basis.

Although the invention is disclosed herein as it applies to the blending of two constituents, it will be apparent from the description that the principles of the invention are readily extendible to the blending of more than two constituents. It will also be apparent that the blending system can be used to blend crude oil with a substance of known composition.

Having described the invention, and a preferred embodiment thereof, what is claimed as new and secured by Letters Patent is:

CLAIMS

1. A method of blending at least a first and a second constituent into a petroleum crude oil mixture, said method comprising the steps of

specifying desired properties of said petroleum crude oil mixture,

performing an on-line NMR measurement of said first constituent to ascertain measured properties of said first constituent, and

on the basis of said measured properties, selectively blending said first constituent with said second constituent to form a petroleum crude oil mixture having said desired properties.

2. The method of claim 1 wherein said step of performing an on-line NMR measurement comprises the steps of

imposing a steady magnetic field on said first constituent,

superimposing a transient magnetic field on said steady magnetic field,

measuring a response of said first constituent to said transient magnetic field, and

on the basis of said response, ascertaining measured properties of said first constituent.

3. The method of claim 1 wherein said step of performing an on-line NMR measurement comprises the steps of

determining information regarding the composition of said first constituent, and

on the basis of said composition information, ascertaining said properties of said first constituent.

4. The method of claim 1 wherein said properties include a chemical composition of said first constituent.

5. The method of claim 1 wherein said properties include physical properties of said first constituent.

6. The method of claim 5 wherein said physical properties are selected from a group consisting of aromaticity, boiling point, flash point, cloud point, viscosity, pour point, API gravity, freeze point, octane, PIONA, and RVP.

7. The method of claim 1 further comprising the step of specifying said desired values of said selected properties on the basis of market conditions.

8. The method of claim 1 wherein said step of selectively blending said first constituent with said second constituent comprises the steps of

performing an on-line NMR measurement of said petroleum mixture to ascertain measured properties of said petroleum mixture,

determining a difference between said measured properties selected of said petroleum mixture and said desired properties, and

on the basis of said difference, adjusting a quantity of said first constituent to be included in said petroleum mixture to reduce said difference.

9. The method of claim 8 wherein said step of performing an on-line NMR measurement of said petroleum crude oil mixture comprises the steps of

imposing a steady magnetic field on said petroleum mixture,

superimposing a transient magnetic field on said steady magnetic field, measuring a response of said petroleum mixture to said transient magnetic field, and

on the basis of said response, ascertaining measured properties of said petroleum mixture.

10. The method of claim 9 wherein said step of ascertaining measured properties of said petroleum mixture comprises the steps of

determining a mixture composition of said petroleum mixture, and

on the basis of said mixture composition, ascertaining measured properties of said petroleum mixture.

11. A system for blending at least a first and second constituent into a petroleum mixture, said system comprising

an optimizer for specifying desired values of selected properties of said petroleum mixture,

a first NMR sensor for on-line measurement of properties of said first constituent, and

a controller in communication with said optimizer and said first NMR sensor, said controller selectively blending, on the basis of said measured properties, said first constituent with said second constituent to form a petroleum mixture having said desired properties.

12. The system of claim 10 wherein said first NMR sensor comprises

means for determining information responsive to the composition of said first constituent, and

means for ascertaining, on the basis of said composition information, properties of said first constituent.

13. The system of claim 12 wherein said ascertaining means comprises means for ascertaining information responsive to a chemical composition of said first constituent.

14. The system of claim 12 wherein said ascertaining means comprises means for ascertaining physical properties of said first constituent.

15. The system of claim 14 wherein said means for ascertaining physical properties of said constituent comprises means for ascertaining a physical property selected from a group consisting of aromaticity, boiling point, flash point, cloud point, viscosity, pour point, API gravity, freeze point, octane, PIONA, and RVP.

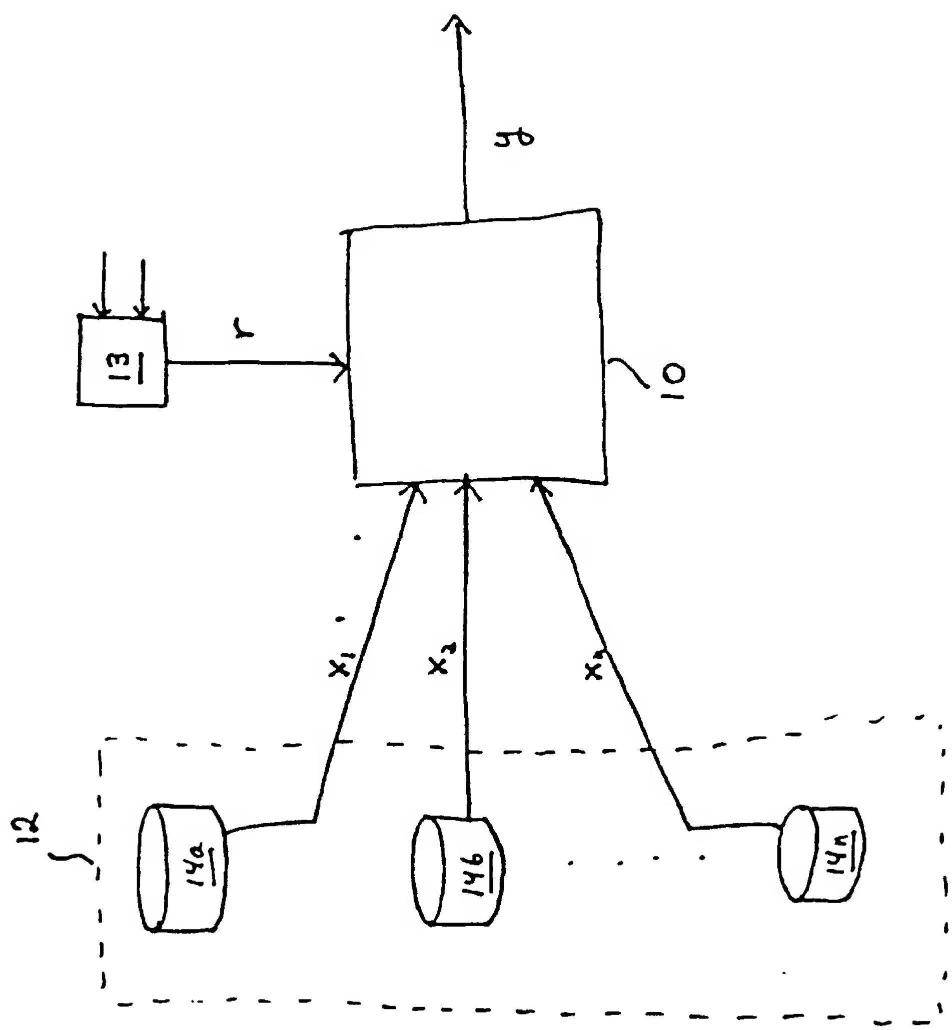
16. The system of claim 11 wherein said optimizer comprises means for specifying said desired properties on the basis of market conditions.

17. The system of claim 11 further comprising

a second NMR sensor for on-line measurement of properties of said blended petroleum mixture, and

feedback means for providing communication between said second NMR sensor and said controller.

FIG. 1



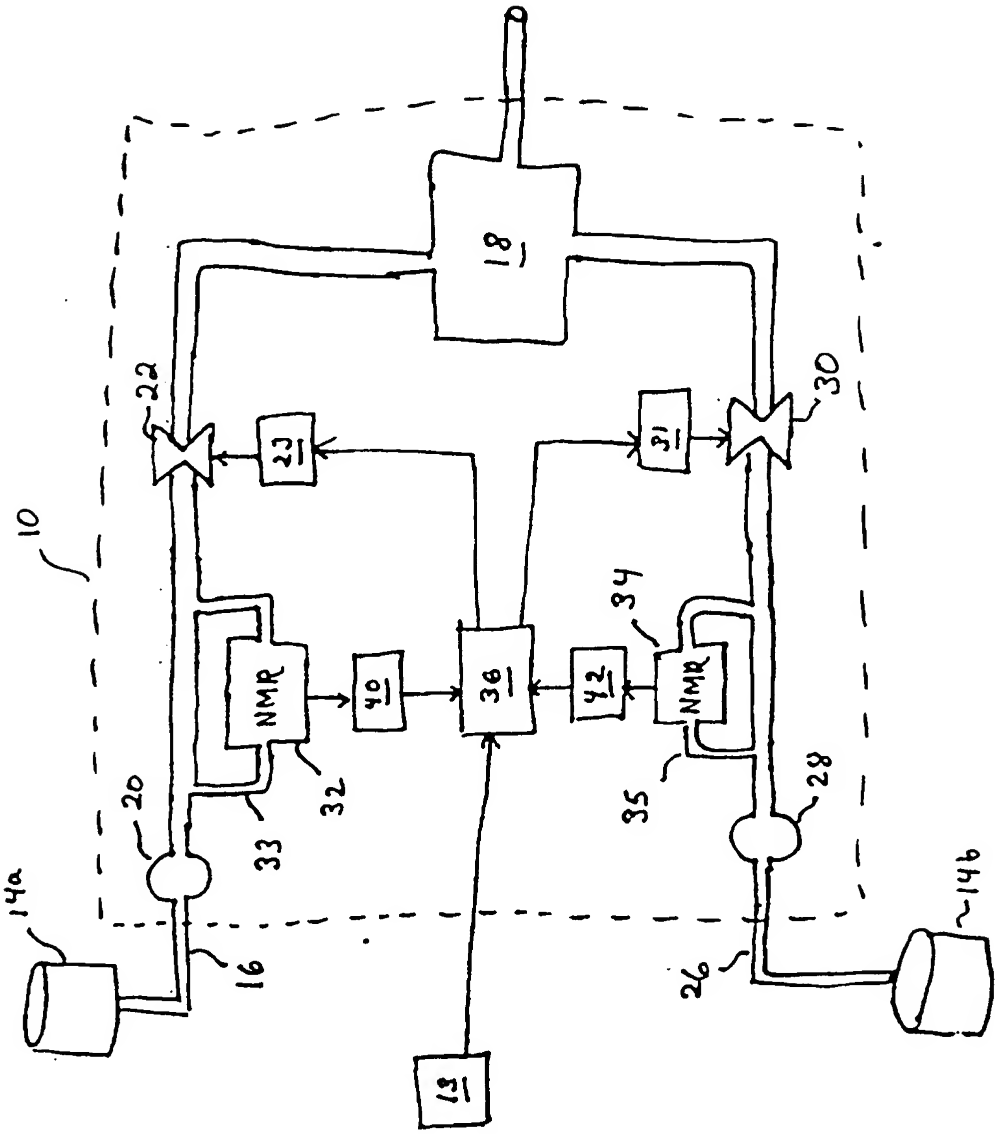


FIG. 2

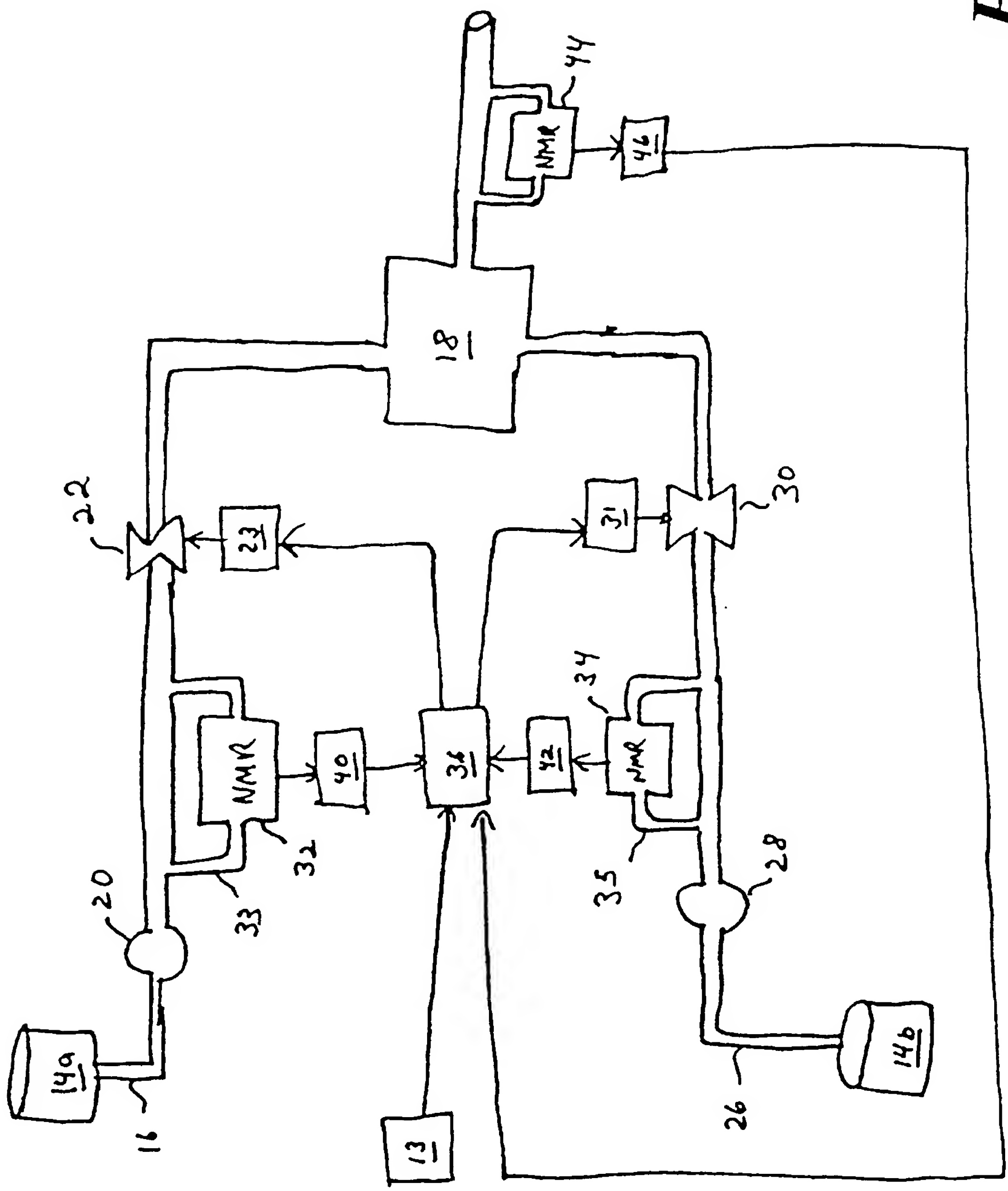

14a
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FIG. 3

INTERNATIONAL SEARCH REPORT

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A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 C10L1/00 B01J19/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 C10L B01J C10G

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 853 337 A (DICKAKIAN GHAZI B) 1 August 1989 (1989-08-01) column 3, line 31 - line 36; claims 1,7,17 ---	1-17
P,A	US 6 159 255 A (PERKINS JONATHAN H) 12 December 2000 (2000-12-12) column 5, line 27 - line 29; claims 1-12 -----	1-17

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
11 April 2001	20/04/2001

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European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Michiels, P

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4853337 A	01-08-1989	EP 0370143 A	30-05-1990
US 6159255 A	12-12-2000	NONE	

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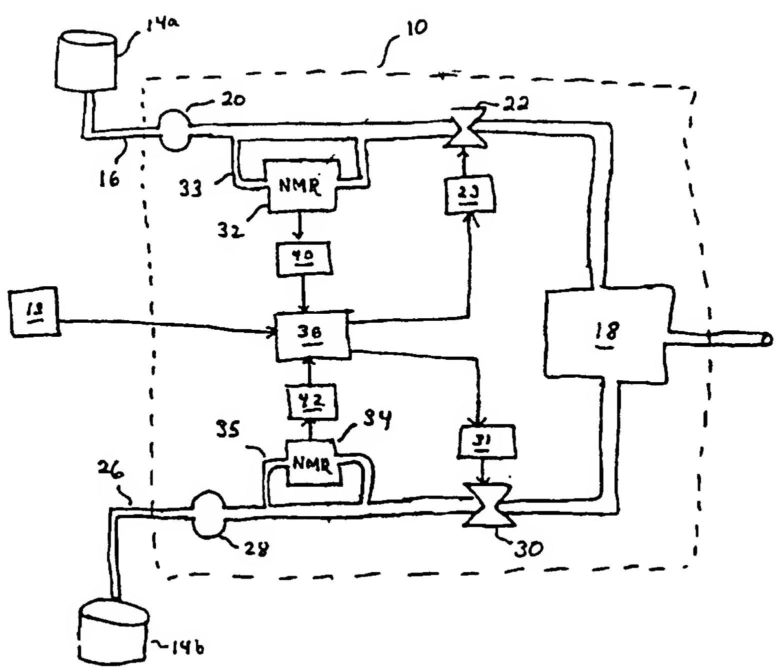
(54) Title: CRUDE OIL BLENDING METHOD AND SYSTEM



(57) Abstract: A method for blending two or more constituents into a petroleum mixture employs nuclear magnetic resonance to obtain real-time estimates of selected properties of at least one of the constituents. A multivariate controller processes these estimates to determine the relative amounts of each constituent that are required to form a petroleum mixture having desired values of those selected properties.

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